Ground Penetrating Radar Survey
of the Proposed Access Road and Visitor Center at Old Mission State Park, Kootenai County, Idaho

Steven L. DeVore
National Park Service
Lincoln, Nebraska
July 2005

Submitted to the Superintendent, Old Mission State Park, Cataldo, Idaho, and State Historic Preservation Office, Boise, Idaho.

Introduction: The present geophysical investigations are conducted as a preliminary reconnaissance of the proposed access road and visitor center at Old Mission State Park in Kootenai County, Idaho (Figure 1). The Old Mission State Park, also referred to as the Cataldo Mission, commemorates the interaction between the Couer d'Alene Indians and the Jesuit Missionaries in the mid-1800s to early 1900s (Cody 1930). The mission site contains the Mission Church, Parish House, two cemeteries, and archeological features associated with other mission buildings and the Native American village (Figure 2).

The Idaho Department of Parks and Recreation is planning on expanding the visitor center facilities at the Old Mission State Park, including a new visitor center and change in the access road to the visitor center (Figure 3). Three archeological sites have been identified in close proximity to the visitor center expansion area (ID Transportation Dept 2005). These include the ethnohistoric village camp of the Couer d'Alene Indians (10KA3), the Coeur d'Alene Mission of the Sacred Heart church (10KA45), and the main mission cemetery (10KA337). Site 10KA3 is identified as a camp site (ID Transportation Dept 2005:2-4) on the northeast hill slope below the Mission church and above the main mission cemetery. The mission cemetery is located in the northeastern corner of the park below the Mission church (ID Transportation Dept 2005: Attachment 11). The cemetery was utilized by the Coeur d'Alene Indians and the Jesuit priests between 1845 and 1877. Over 300 individuals are interred in the cemetery.

The Scope-of-Work (ID Dept Parks/Rec 2005) for the archeological investigations calls for the non-invasive sub-surface investigations in the vicinity of the mission cemetery and planned access road route. Due to concerns about unmarked graves in the vicinity of the main cemetery on the hillside below the Mission Church, which might be impacted by the Park's proposed visitor center and access road development, a ground penetrating radar survey was utilized in the proposed access road area, the main cemetery, and along other portions of the proposed visitor center construction zone. The ground penetrating radar survey was conducted on June 20, 2005. In attendance were Jim Thomas, development planner for Idaho Department of Parks & Recreation; Suzi Neitzel, Idaho Deputy State Historic Preservation Officer; Travis Pitkin, Idaho State Historic Preservation Office archeologist; Marc Munch, Idaho Transportation Department archeologist; Jason Lyon, Nez Perce National Historical Park archeologist; Quanah

Mathejon, Coeur d'Alene Tribe archeologist, and Felix Aripa, Coeur d'Alene Tribe member and consultant. The gpr survey was conducted at the request of the Nez Perce National Historical Park archeologist and the Old Mission State Park staff in conjunction with the Idaho State Historic Preservation Office staff.

Survey area: The ground penetrating radar (gpr) survey covered an area of 20 meter (north-south) by 80 meters (east-west) on the hill slope above the main mission cemetery (Figure 4). Three ground penetrating radar profiles were also collected inside of the main cemetery along locations of known/marked graves for comparison purposes with gpr profile data from the proposed access road area. In addition, a series of random transects were conducted in the area west of the access road in the general vicinity of the proposed visitor center construction zone. The construction area had been staked out by the park staff prior to conducting the geophysical survey (Figure 5).

The project area is located within the Northern Rocky Mountains province of the Rocky Mountain System (Fenneman 1931:183-224). The region is generally rough with forested mountains or hilly terrain. The valleys are narrow and open to the west (Weisel 1981:1). The mountainous areas consist of metamorphic and metasedimentary rocks. The Coeur d'Alene River flows through a broad flood plain from east to west. The park lies on the Mission Flats along the right bank of the Coeur d'Alene River.

The project area is also located in the mountainous parts of northern Idaho, surrounding states of Washington and Montana, and Canada in the Montanian biotic province (Dice 1943:34-37). Native vegetation consisted of numerous species of conifers (e.g., western hemlock, western redcedar, western white pine, Douglas fur, and western larch). Native forage also included sedges, willow, maple, and stem ceanothus. Native animals included white-tailed deer, black bear, elk, forest grouse, and numerous other small mammals and songbirds (Shelford 1963:152-160).

Soil type: The project area lies within the Slickens-Xerofluvents soil association of "slickens and nearly level, poorly drained stratified soils that formed in alluvium" (Weisel 1981:11) on the low stream terraces of the Coeur d'Alene River. The ground penetrating radar survey area at the Old Mission State Park lies within the Chatcolet cobby loam soil mapping unit, with 7 to 25 percent slopes (Weisel 1981:20,107-108). This very deep, moderately well-drained soil formed on glaciolacustrine terraces in volcanic ash and loess over lake lain sediments. Permeability is moderately slow. Available water capacity is moderate and fertility is medium. Runoff is rapid to very rapid. Water erosion is high to very high.

Survey methodology:

The geophysical grids were established across the proposed access road with a portable surveying compass. For the present geophysical survey, wooden hub stakes were placed at the 20-meter grid corners. Twenty-meter ropes were placed along the east-west lines connecting the grid corners. These ropes formed the north and south boundaries of each grid and served as guides during the data collection phase of the survey. The ropes were

marked with different color tape at half-meter and meter increments designed to help guide the survey effort. Two-liter pop bottles with plastic pin flags taped to them served as targets marking the end of each survey traverse. The one at the south end of the grid was placed on each half-meter mark while the other bottle was placed on the meter mark at the north end of the grid. The bottles with the pin flags were also used as traverse line guides during data acquisition.

Survey grid: Four 20 by 20 m grids were investigated during the gpr survey of the proposed access road at Old Mission State Park (Figure 6). The grids were combined into one grid block for additional ease of data acquisition. Approximately 0.16 hectares (1,600 m^2) were surveyed with the ground penetrating radar system. Although the main focus of the gpr survey efforts concentrated on the proposed access road alignment, three profile lines were collected in the main mission cemetery north of geophysical grid block. The lines were conducted over the marked graves in the south central section of the cemetery. It is hoped that the gpr signature from these known graves will be useful in the identification and interpretation of gpr anomalies in the geophysical grid block.

Instrument: Geophysical Survey Systems Inc. (GSSI) TerraSIRch SIR System-3000 ground penetrating radar cart system with a 400 mHz antenna (GSSI 2003a).

Specifications: SIR 3000: System hardware contains a 512 mb compact flash memory card as its internal memory. Accepts industry standard compact flash memory card up to 2 gb. Processor is a 32-bit Intel StrongArm PISC 206 mHz processor with enhanced 8.4" TFT display, 800 x 600 resolution, and 64k colors. The processor also produces linescan and O-scope displays. The gpr system uses one channel. It also uses the GSSI Model 623 survey cart with survey wheel for mounting the antenna and control unit. 400 mHz Model 5103 ground coupled antenna: Has a depth of view of approximately 4 m assuming a ground dielectric constant of 5 with a range of 50 ns, 512 samples per scan, 16 bit resolution; 5 gain points, 100 mHz vertical high pass filter, 800 mHz vertical low pass filter, 64 scans per second, and 100 kHz transmit rate.

Survey type: ground penetrating radar

Operator: Steven L. De Vore

The ground-penetrating survey is an active geophysical technique (see Bevan 1998:43-57; Clark 2000:118-120; Conyers 2004; Conyers and Goodman 1997; Gaffney and Gater 2003:74-76; Heimmer and DeVore 1995:42-47,2000:63-64; Kvamme 2001:363-365; Lowrie 1997:221-222; Milson 1996:131-140; Mussett and Khan 2000:227-231; and Scollar et al. 1990:575-584 for more details of ground penetrating radar surveys). The gpr unit operated an antenna at a nominal frequency of 400 megahertz (mHz). The antenna was mounted in a cart that recorded the location of the radar unit along the grid line (Figure 7). The gpr profiles were collected along 0.5 meter traverses beginning in the southwest corner of the grid block. The data were collected in a zigzag or bidirectional fashion with the surveyor alternating the direction of travel for each traverse

across the grid. A total of 161 radar profiles were collected across the project survey area.

GPR surveys generally represent a trade-off between depth of detection and detail. Lower frequency antennas permit detection of features at greater depths but they cannot resolve objects or strata that are as small as those detectable by higher frequency antennas. Actual maximum depth of detection also depends upon the electrical properties of the soil. If one has an open excavation, one can place a steel rod in the excavation wall at a known depth and use the observed radar reflection to calibrate the radar charts. When it is not possible to place a target at a known depth, one can use values from comparable soils. Reasonable estimates of the velocity of the radar signal in the site's soil can be achieved by this method. Using one of the hyperbolas on a radargram profile (Goodman 2004:76), the velocity was calculated to be approximately 7 cm per ns. For a time slice between 5 and 15 ns with the center at 10 ns (two way travel time), the approximate depth to the center of the gpr slice would be 35 cm. With a time window of 70 ns, the gpr profile extended to a depth of 2.45 meters

The survey cart contained a data-logger (SIR 3000) with a display that allowed the results to be viewed almost immediately after they were recorded. The SIR 3000 was set to collect gpr data with the 400 mHz antenna at an antenna transmit rate of 100 mHz and the distance mode selected for use of the survey wheel on the cart. The scan menu was set with 512 samples, 16 bit format, 70 ns range or window, a dielectric constant of 8 (the default value), a scan rate of 100, and 50 scans per meter. In the gain menu, the gain was set to manual with a default value of 3. The gpr system was moved around the grid prior to the start of the survey to adjust the gain. If a location caused the trace wave to go off the screen, the gain was set to auto and then back to manual. The position was set to the manual mode with the offset value at the factory default and the surface display option set to zero. The filters were left at the default settings. With the setup completed, the run/stop button at the bottom of the display screen was selected and the collect mode was initiated. The gpr unit was moved across the grid and at the end of the traverse, the next file button was selected and data acquisition was halted. The gpr unit was placed at the start of the next line before saving the profile. Once the profile data was saved, the gpr unit was ready to collect the next profile line.   The gpr data were recorded on a 512 mb compact flash card and transferred to a lap-top computer at the end of the survey.

The gpr radargram profile line data are imported into GPR-SLICE (Goodman 2005) for processing. The first step in GPR-SLICE is to create a new survey project under the file menu. This step identifies the file name and folder locations. The next step is to create the information file. The number of profiles are entered, along with the file identifier name, .dzt for GSSI radargrams, the profile naming increment of 1, the first radargram name (generally this is 1), direction of profiling, x and y beginning and ending coordinates, units per marker (set to 1), the time window opening in nanoseconds (70 ns), samples per scan (512 s/scn), the number of scans per meter (these profiles were collected at 50 scans per meter), type of data (16 bit). Selecting the create info file button completes the information file for the project. The information file can be edited if necessary to correct profile lengths. The 16-bit GSSI radargrams are imported into the

GPR-SLICE project folder for further processing. The 16-bit data are then converted to remove extraneous header information and to regain the data. During the conversion process, the signal is enhanced by applying gain to the radargrams. Once the conversion process is completed, the next step is to reverse the profile data. Since the radargrams were collected in the zigzag mode, these have every even line reversed. The reverse map button shows the radargrams that are going to be reversed. The next step is to insert navigation markers into the resample radargrams. The GSSI SIR 3000 and the artificial markers button are selected to apply markers based on the total number of scans in the radargram. The show markers button allows one to view an example of a radargram with the artificial markers in place. The next step is to create the time slices of the profile data (Conyers and Goodman 1997; Goodman et al. 1995). The program resamples the radargrams to a constant number of scans between the markers and collects the time slice information from the individual radargrams. The number of slices is set to 20 slices. The slice thickness is set to 30 to allow for adequate overlap between the slices. The offset value on the radargram where the first ground reflection occurs is viewed in the search 0 ns subroutine. This value is used to identify the first radargram sample at the ground surface. The end sample is 512. The offset value in entered in the samples to 0 ns box. The cut parameter is set to square amplitude with the cuts per mark set to 4. The slice/resample button is selected for processing the radargrams. The final step in the slice menu is to create the XYZ data file. The grid menu is entered next in the processing steps. The beginning and ending values for the x and y coordinate are entered. The help set button is selected to set the x search radius, y search radius and the blanking radius. The grid cell size is set to 0.1 and the search type is rectangular. The number of grids equal 20 for the number of slices, and the starting grid number is 1. The Kriging algorithm is utilized to estimate the interpolated data. The Varigram button is selected to set the Kriging range, nugget and sill parameters. The start gridding button is selected and the gridded dataset is created. In this menu, a low pass filter may be applied to the dataset to smooth noisy data in the time slices. At this point, one may view the time sliced radar data in the pixel map menu (Figure 8). In addition, the original processed grids and the low pass filtered grids can be exported in the Surfer grid format. The gain may be readjusted for any time slice. This is done in the transforms submenu. The interpolations value is set to 5 and the interpolate grids routine is selected. The new interpolated grids are all normalized. The next step is to create the 3D dataset in the grid menu. The number of grids is now equal to 95 ((20-1)*5). The 3D database is created under the create 3D file routine. The 3D data may be displayed as a series of z slices in the creation of a 3D cube with a jpeg output for animating the 3D cube.

Interpretations: Andrew David (1995:30) defines interpretation as a "holistic process and its outcome should represent the combined influence of several factors, being arrived at through consultation with others where necessary." Interpretation may be divided into two different types consisting of the geophysical interpretation of the data and the archaeological interpretation of the data. At a simplistic level, geophysical interpretation involves the identification of the factors causing changes in the geophysical data. Archeological interpretation takes the geophysical results and tries to apply cultural attributes or causes. In both cases, interpretation requires both experience with the operation of geophysical equipment, data processing, and archeological methodology;

and knowledge of the geophysical techniques and properties, as well as known and expected archeology. Although there is variation between sites, several factors should be considered in the interpretation of the geophysical data. These may be divided between natural factors, such as geology, soil type, geomorphology, climate, surface conditions, topography, soil magnetic susceptibility, seasonality, and cultural factors including known and inferred archeology, landscape history, survey methodology, data treatment, modern interference, etc. (David 1995:30). It should also be pointed out that refinements in the geophysical interpretations are dependent on the feedback from subsequent archeological investigations.

Analysis of the three gpr profile lines collected in the main mission cemetery indicated the presence of a series of marked and unmarked grave locations (Figure 9). Although some of the unmarked graves were associated with slight depressions, no surface indications (i.e., surface depressions) of other unmarked graves were present. Comparing individual profiles to a time slice of the three lines, high amplitude anomalies were identified in the profiles. The majority of these anomalies in Lines 1 and 2 correspond to marked graves and unmarked grave with surface depressions. There did not appear to be any unmarked graves identified along Line 3 near the southern fence line of the cemetery.

Initial examination of the geophysical data indicates that several noticeable features within the gpr block survey area are present in the geophysical data. The interpretation of the data reveals both linear and point amplitude anomalies. The rock trail that leads from the cemetery to the Mission church is clearly visible in the five selected time slices (Figure 10). Although the thickness of the rock trail does not extend throughout the vertical profile in the ground, the resulting data reflect various combinations of multiple reflections and refractions caused by the different materials and soil textures. Three high amplitude reflections are also noted in Slice 5 and 10. These targets are present in the eastern section of the grid and could possibly represent archeological features of interest. It is possible that one or all of these targets could represent graves but additional archeological verification in the form of some type of excavation or ground truthing will be needed to determine their true nature. There appears to be some difference in the materials between the eastern part of the survey area and the western part. This is represented by a dashed line on the illustrated slices. Finally, a linear anomaly was also noted in Slice 15. This anomaly is fairly deep in the gpr profile and may have a geological explanation.

Conclusions: On June 20th, 2005, the author conducted ground penetrating radar survey at Old Mission State Park, Kootenai County, Idaho. The investigations were conduced as part of the archeological investigations of the affected area associated with the park's proposed visitor center expansion project. Four 20 by 20 m grid units were surveyed with the Geophysical Survey Systems Inc. TerraSIRch SIR System-3000 ground penetrating radar cart system with a 400 mHz antenna on the side slope between the main mission cemetery and the Mission church on top of the ridge.

Both high and low amplitude strength gpr anomalies were detected during the investigations. Linear anomalies included the rock trail and deeper geological features.

Three high amplitude, small point gpr anomalies may represent ethnohistoric features associated with the Couer d'Alene village or grave locations outside the fenced main mission cemetery.

This report has provided a cursory review and analysis of the ground penetrating radar data collected at the Old Mission State Park. There is much more information to be gleaned from analysis of the data than was provided by the allotted time to conduct the survey and analyze the data. Overall, the project location on the side slope is well suited for geophysical investigations; however, without further archeological ground truthing of the various anomalies, it is extremely difficult to determine the true nature of these anomalies.

References Cited:

Bevan, Bruce W.
  1991   The Search for Graves. *Geophysics* 56(9):1310-1319.
  1998   *Geophysical Exploration for Archaeology: An Introduction to Geophysical Exploration*. Special Report No. 1. Midwest Archeological Center, Lincoln, Nebraska.

Clark, Anthony
  2000   *Seeing beneath the Soil: Prospecting Methods in Archaeology*. Reprint. Routledge, London. Originally published in 1996 by B. T. Batsford Ltd., London.

Cody, Edmund R.
  1930   *History of the Coeur d'Alene Mission of the Sacred Heart*. Progressive Printing & Supplies, Kellogg, Idaho.

Conyers, Lawrence B.
  2004   *Ground-Penetrating Radar for Archaeology*. AltaMira Press, Walnut Creek, California.

Conyers, Lawrence B., and Dean Goodman
  1997   *Ground-Penetrating Radar: An Introduction for Archaeologists*. AltaMira Press, Walnut Creek, California.

David, Andrew
  1995   *Geophysical Survey in Archaeological Field Evaluation*. Research & Professional Services Guidelines No. 1. English Heritage, Swindon, England.

Dice, Lee R.
  1943   *The Biotic Provinces of North America*. University of Michigan Press, Ann Arbor.

Fenneman, Nevin M.
  1931   *Physiography of Western United States*. McGraw-Hill Book Company, New York.

Gaffney, Chris, and John Gater
  2003   *Revealing the Buried Past: Geophysics for Archaeologists*. Tempus Publishing, Stroud, Great Britain.

Golden Software
  2002   *Surfer 8 User's Guide: Contouring and 3D Surface Mapping for Scientists and Engineers*. Golden Software, Golden, Colorado.

Goodman, Dean
2005 *GPR-SLICE – Ground Penetrating Radar Imaging Software Quickstart Users Manual, Ver. 5.0.* Geophysical Archaeometry Laboratory, Woodland Hills, California.

Goodman, D., Y. Nishimura, and J. D. Rogers
1995 GPR Time Slices in Archaeological Prospection. *Archaeological Prospection* 2(2):85-89.

GSSI
2003a *TerraSIRch SIR System-3000 User's Manual.* Geophysical Survey Systems, Inc., North Salem, New Hampshire.
2003b *RADAN for Windows Version 5.0 User's Manual.* Geophysical Survey Systems, Inc., North Salem, New Hampshire.
2003c *3D QuickDraw for RADAN 5.0 User's Manual.* Geophysical Survey Systems, Inc., North Salem, New Hampshire.

Heimmer, Don H., and Steven L. DeVore
1995 *Near-Surface, High Resolution Geophysical Methods for Cultural Resource Management and Archeological Investigations.* Revised Edition. National Park Service, Denver.
2000 Near-Surface, High Resolution Geophysical Methods for Cultural Resource Management and Archeological Investigations. In *Science and Technology in Historic Preservation*, edited by Ray A. Williamson and Paul R, Nickens, pp. 53-73. Advances in Archaeological and Museum Science Volume 4. Kluwer Academic/Plenium Publishers, New York.

ID Dept Parks/Rec
2005 Plan for Archaeological Investigations at Old Mission State Park: Old Mission State Park Visitor Center Expansion Project STP-2800(131), Key #8905, Kootenai County, Idaho. Ms. on file, Old Mission State Park, Cataldo, Idaho.

ID Transportation Dept
2005 *Summary of Previous Archaeological Investigations and Recommendations for Expanded Visitor Facilities Archaeological Investigations at Old Mission State Park.* Idaho Transportation Department, Bois.

Kvamme, Kenneth L.
2001 Current Practices in Archaeogeophysics: Magnetic, Resistivity, Conductivity, and Ground-Penetrating Radar. In *Earth Sciences and Archaeology*, edited by Paul Goldberg, Vance T. Holliday, and C. Reid Ferring, pp. 353-384. Kluwer Academic/Plenium Publishers, New York.
2003 Geophysical Surveys as Landscape Archaeology. *American Antiquity* 68(3):435-457.

Lowrie, William
  1997   *Fundamentals of Geophysics*. Cambridge University Press, Cambridge,
                United Kingdom.

Milsom, John
  1996   *Field Geophysics*. Second Edition. John Wiley & Sons, Chichester,
                United Kingdom.

Mussett, Alan E., and M. Aftab Khan
  2000   *Looking into the Earth: An Introduction to Geological Geophysics*.
                Cambridge University Press, Cambridge, United Kingdom.

Scollar, I., A. Tabbagh, A. Hesse, and I. Herzog
  1990   *Archaeological Prospection and Remote Sensing*. Topics in Remote
                Sensing 2. Cambridge University Press, Cambridge, Great Britain.

Shelford, Victor E.
  1963   *The Ecology of North America*. University of Illinois Press, Urbana.

Weisel, Charles J.
  1981   *Soil Survey of Kootenai County Area, Idaho*. U.S. Government Printing
                Office, Washington, D.C.

Figures

a) Topographic map of Old Mission State Park, Kootenai County, Idaho
(USGS topographic map 2 km SW of Cataldo, Idaho, 01 JUL 1987).

b) Aerial photograph of Old Mission State Park, Kootenai County, Idaho
(USGS aerial photograph 2 km W of Cataldo, Idaho, 21 JUN1992).

Figure 1. Location of ground penetrating radar project area at Old Mission State Park,
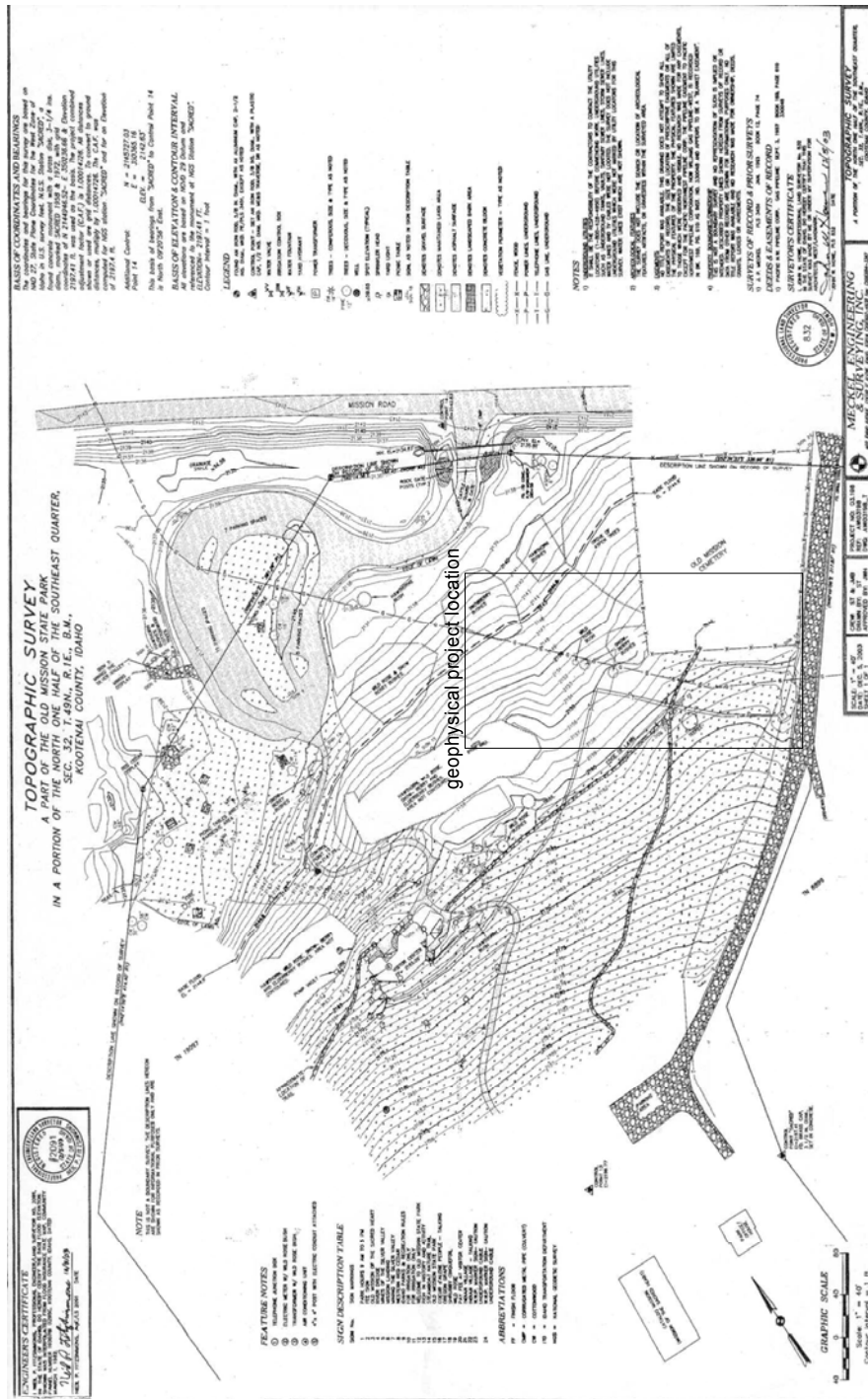Kootenai County, Idaho.

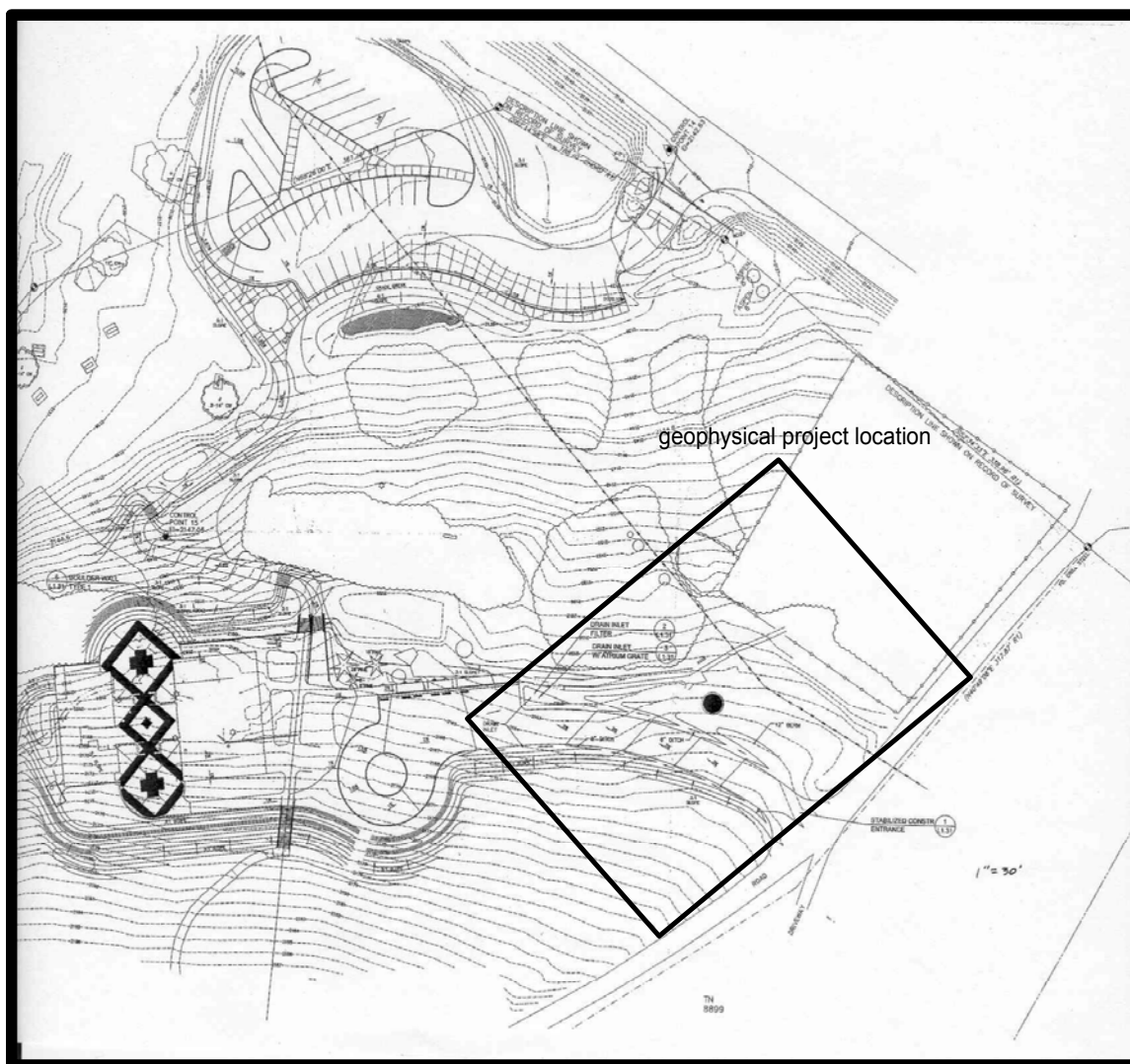Figure 2. Ground penetrating radar survey area at Old Mission State Park, Kootenai County, Idaho.

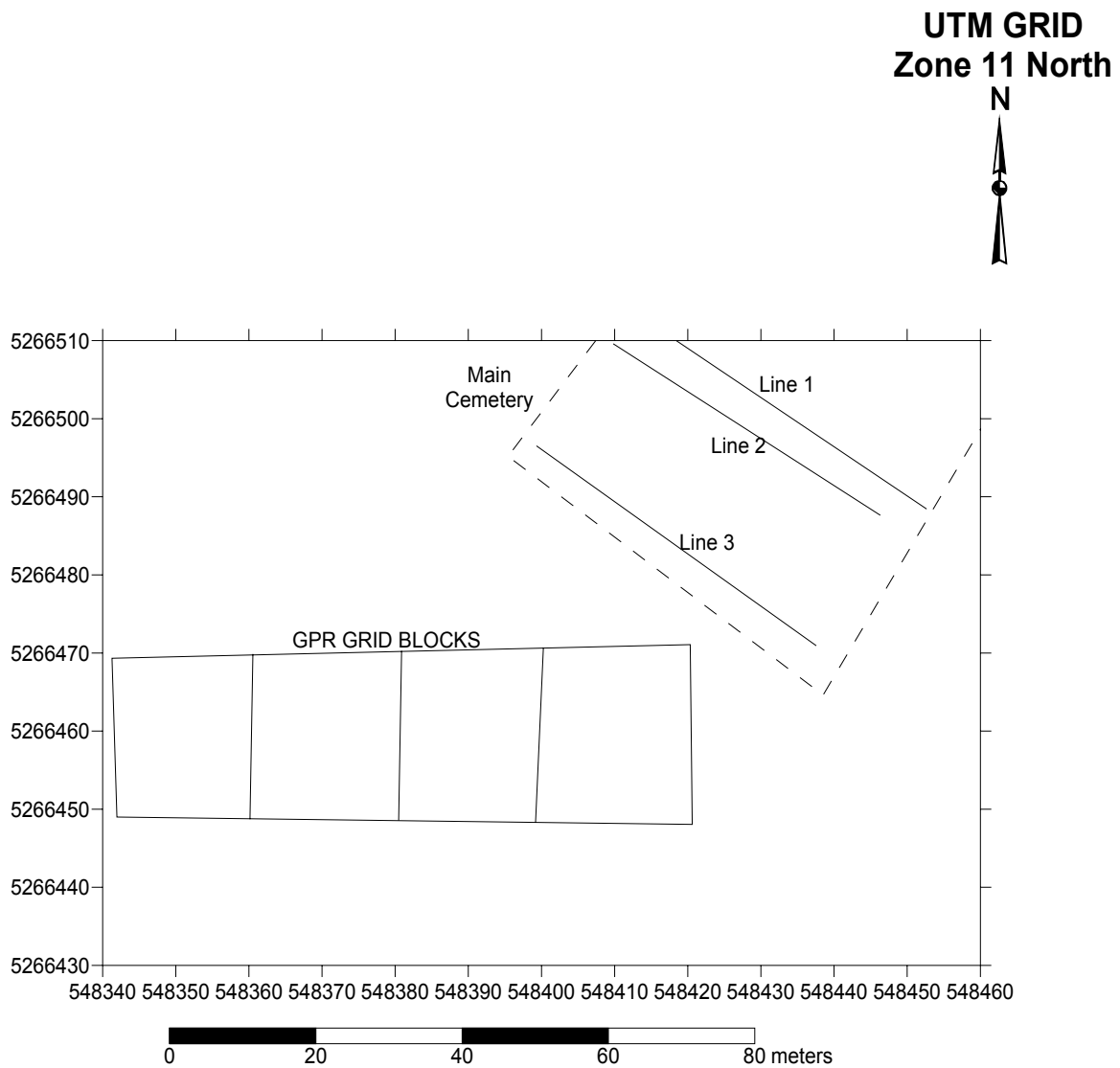Figure 3. Location of the ground penetrating radar survey area and proposed visitor center construction.

UTM GRID
Zone 11 North

N

5266510

Main
Cemetery

Line 1

5266500

Line 2

5266490

Line 3

5266480

5266470

GPR GRID BLOCKS

5266460

5266450

5266440

5266430

548340 548350 548360 548370 548380 548390 548400 548410 548420 548430 548440 548450 548460

0   20   40   60   80 meters

Figure 4. UTM location of geophysical grid and profile lines at Old Mission State Park,
Kootenai County, Idaho.

Figure 5. General view of geophysical project area, view to the north northeast.

Figure 6. Access road alignment and location of ground penetrating radar survey, view to the east.

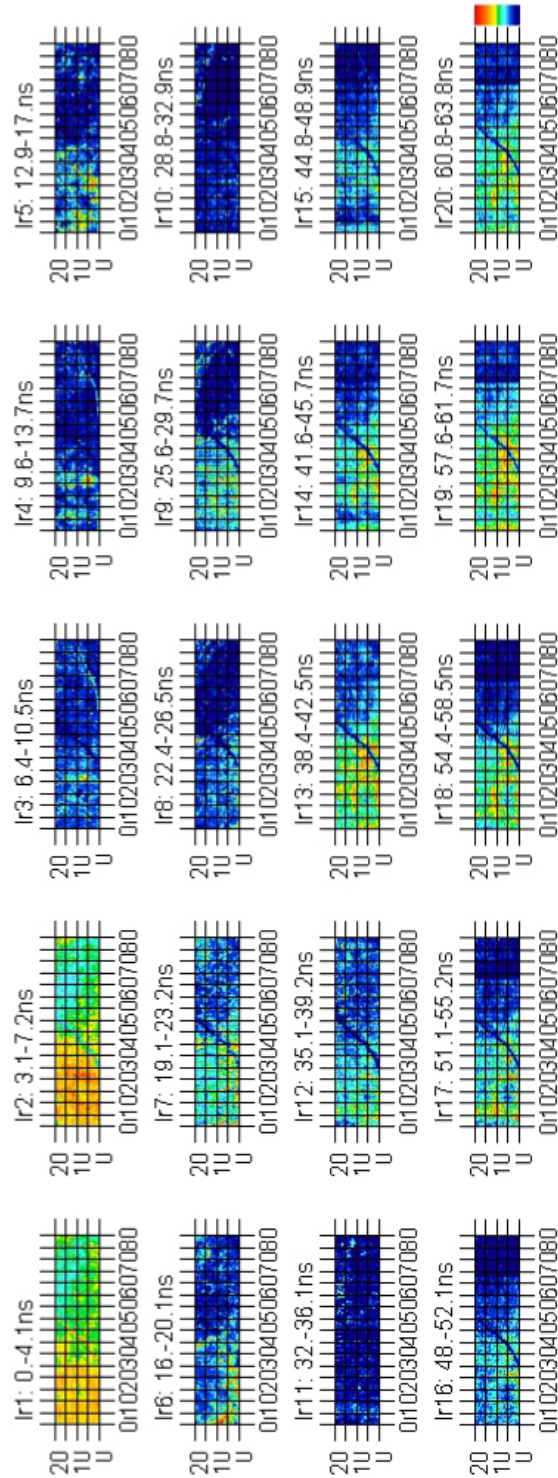Figure 7. Using the ground penetrating radar, view to the south.
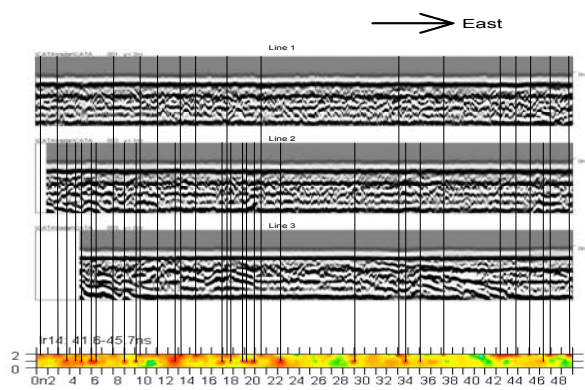
Figure 8. Ground penetrating radar time slices.

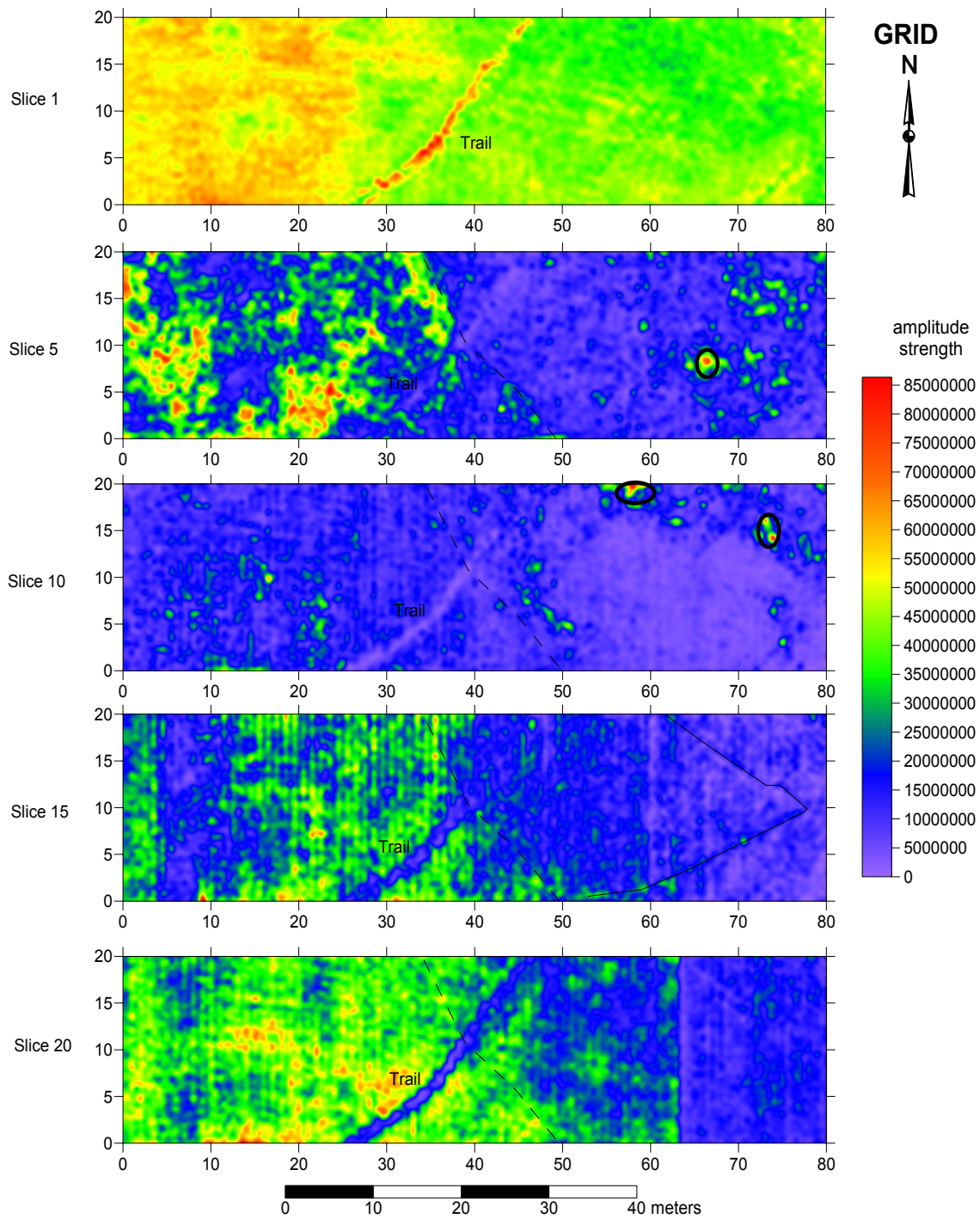Figure 9. Profiles from main mission cemetery and time slice.

Figure 10. Selected time slices with interpretations of ground penetrating radar data.